Session 30 Overview

Silicon for Biology

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The increasing world-wide focus on human healthcare and well-being is providing a major impetus for the development of new types of prosthetic microsystems, diagnostic systems, and body-sensor networking. The technology being brought to bear on this challenge ranges from traditional CMOS circuits to biologically inspired architectures, RF, optics and MEMS. Low cost, small form-factor, low power consumption and reusability are key enablers. Complete integrated microsystems, optimized for specific applications, offers the potential for significant impact on future medical care.

The six presentations in this session provide a broad perspective on recent advances in achieving this vision, ranging from implanted microelectronic devices, human body communications, and reusable diagnostic systems. Wireless technology of various types plays an important role in achieving a convenient, sterile interface between silicon and humans.

In Paper 30.1, an implantable prosthesis processor for sensing and translating neural signals into motor commands is described. The data compression factor is on the order of 10^6, translating 80Mb/s neural data to < 20b/s for the intended movement signals. In Paper 30.2, a neuron signal-processing IC with 433MHz FSK wireless transceiver is integrated with a 10×10 platinum-tipped silicon electrode array. It can provide neuroprosthetic devices with 330kb/s data rates while consuming 13.5mW.

In Paper 30.3, a mixed-mode cochlear-like preprocessing chip is presented for possible application to speech-recognition systems. Its biomorphic architecture adopts active bidirectional coupling and enhances formant perception in noisy environments.

In Paper 30.4, a convenient short-distance communication scheme uses the human body as the data transmission medium. A 2Mb/s wideband pulse transceiver uses a single electrode structure with low power consumption.

A label-free electrochemical CMOS DNA detector is presented in Paper 30.5. This $25\times3mm^2$ IC, fabricated in $1\mu m$ 2M CMOS process provides quantitative analysis with high sensitivity and accuracy. Paper 30.6 is another label-free detection system for C-reactive protein that makes use of a MEMS/electronic hybrid system with a wireless ASK transceiver. Disease-sensitive anti-CRP is deposited on the tip of the MEMS cantilever, and it's deflection is monitored with laser optics. Concentrations of 1ug/mL to 500ug/mL can be detected; a 1 V, 0.2Hz signal is applied for reuse of the cantilever.

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30.1 Neurons to Silicon: Implantable Prosthesis Processor **1:30 PM**
T. Meng, Stanford University, Stanford, CA

A processor architecture for neural prosthesis control is described. It implements real-time neural decoding from a permanently implanted electrode array to reduce the data rate from 80Mb/s to 20b/s, minimizing the wireless communication requirements. The neural signals are digitized by a 100-channel 100kS/s adaptive-resolution ADC array consuming 1μW per channel.

30.2 A Low-Power Integrated Circuit for a Wireless 100-Electrode Neural Recording System **2:00 PM**
R. Harrison, University of Utah, Salt Lake City, UT

An implantable IC receives power and commands wirelessly through an ASK inductive link, and transmits amplified neural data using a 433MHz FSK transmitter. A 10×10 array of platinum-tipped silicon electrodes interfaces with a flip-chip bonded 4.7×5.9mm^2 0.5μm 3M2P CMOS 13.5mW IC containing 88 neural amplifiers, 9b ADC and spike detectors used for data reduction.

30.3 A 360-Channel Speech Preprocessor that Emulates the Cochlear Amplifier **2:30 PM**
B. Wen, University of Pennsylvania, Philadelphia, PA

A cochlea-based preprocessor for speech recognition emulates the fluid ducts with two 4680-element diffusive grids, the basilar membrane with 360 2nd-order sections, and the auditory nerve with 2160 pulse-frequency modulators. Integrated in 10.9mm^2 in 0.25μm CMOS and consuming 52mW, this silicon cochlea employs active bidirectional coupling, a selective amplification mechanism that sharpens tuning (Q_{10} is 2.7) and controls gain (24dB compression).

30.4 A 2Mb/s Wideband Pulse Transceiver with Direct-Coupled Interface for Human-Body Communications **3:15 PM**
S-J. Song, KAIST, Daejeon, Korea

A battery-powered wideband pulse transceiver with a direct-coupled interface is presented for human-body communications. The optimum channel bandwidth of 10kHz to 100MHz is identified as the Bodywire Channel. The transceiver based on all-digital CDR circuit with quadratic sampling technique has 2Mb/s data rate at a BER of 10^{-7}. The 0.25μm CMOS transceiver occupies 0.85mm^2 and consumes less than 0.2mW from a 1V supply.

30.5 A CMOS Integrated DNA chip for Quantitative DNA Analysis **3:45 PM**
N. Gemma, Toshiba, Kawasaki, Japan

Quantitative gene expression analysis, based on an electrochemical DNA-detection method uses immobilized DNA probes on Au electrodes with diameters from 200μm to 2μm. Cyclic voltammetry is used to measure anodic current from the intercalators. The 25×3mm^2 IC, fabricated in 1μm 2M CMOS, contains 40 electrodes, 1600 transistors and dissipates 150mW at ±3.3V.

30.6 A Wireless Bio-MEMS Sensor for C-Reactive Protein Detection Based on Nanomechanics **4:15 PM**
L-S. Huang, National Taiwan University, Taipei, Taiwan

A quick (<30min.), label-free detection of disease-related C-reactive proteins (CRP) is achieved using a 200μm MEMS microcantilever housed in a 7×7mm^2 reaction chamber. The deflection of the cantilever due to specific CRP/anti-CRP binding is detected using a position-sensitive photodiode and the converted bio-signal is transmitted by a wireless ASK transceiver IC fabricated in a 0.18μm CMOS process. CRP concentrations from 1μg/mL to 500μg/mL can be detected. A 0.2Hz 1V ac signal is applied to the bio-MEMS sensor to unbind CRP from the cantilever for reuse.